L'industrie lourde donne au Québec un avantage concurrentiel de long terme dans un avenir à faible teneur en carbone

La décarbonisation de l'économie ne signifie pas la désindustrialisation

Mémoire de l'Association des consommateurs industriels de gaz – ACIG

Présenté à

Transition énergétique Québec

Consultation publique visant l'élaboration du premier plan directeur de Transition énergétique Québec - TEQ

IGUA | ACIG

8 décembre 2017

Introduction

Objectif du mémoire

L'ACIG apprécie l'opportunité de pouvoir déposer ses commentaires pour considération par Transition énergétique Québec (TEQ) dans l'élaboration de son premier plan directeur.

Ce premier plan directeur préparé par TEQ donnera l'orientation à suivre et les actions à prioriser dans le but d'atteindre les objectifs énoncés par le gouvernement dans la politique énergétique 2016-2030.

D'entrée de jeu, l'ACIG soutient l'action contre le changement climatique. L'ACIG est toutefois d'avis que la gestion des émissions de carbone et le développement économique sont complémentaires et non pas mutuellement exclusifs. C'est dans ce contexte que l'ACIG participe à la consultation de Transition énergétique Québec.

Qui est l'ACIG ?

Créée en 1973, l'Association des consommateurs industriels de gaz représente vingt-deux des plus grands consommateurs industriels de gaz au Québec et en Ontario qui exploitent des installations à forte intensité énergétique et qui sont exposés au commerce international.

Le mandat de l'ACIG inclut :

- Une participation efficace aux travaux réglementaires (Régie de l'énergie, Commission de l'énergie de l'Ontario, Office national de l'énergie);
- L'assurance d'une voix cohérente sur les enjeux relatifs au gaz naturel, à l'énergie et aux questions environnementales qui ont un impact sur le coût du gaz livré au client.

Les membres de l'ACIG proviennent des secteurs de l'industrie minière, des métaux, de la chimie et pétrochimie, des produits forestiers et du secteur manufacturier. Une liste des membres est présentée en annexe du mémoire.

Les membres de l'ACIG sont :

- Des entreprises internationales de produits dont les marchés sont cycliques;
- En concurrence internationale pour les marchés et pour les capitaux d'investissement au sein de leurs entreprises;
- De grands employeurs dans les régions :
    - Les membres de l'ACIG soutiennent plus de 20,000 emplois au Québec, et sont présents dans plusieurs régions, dont l'Abitibi-Témiscamingue, le Centre du Québec, l'Estrie, la Montérégie, Montréal, l'Outaouais et le Saguenay;
    - Collectivement, ils injectent annuellement plus de 7 $ milliard à l'économie du Québec;
    - Leur consommation agrégée de gaz naturel est supérieure à 150 PJ/an (dont 74 PJ/an au Québec);
- L'accès à un approvisionnement énergétique fiable à coût compétitif est essentiel puisqu'il a une incidence sur le maintien de leurs activités et de leur développement.

Le coût total du gaz livré à leurs installations est très important au maintien de leur compétitivité. Les membres de l'ACIG valorisent tous les efforts déployés par les distributeurs gaziers au Québec à minimiser les coûts d'opération et ceux des programmes offerts. L'ACIG encourage Transition énergétique Québec à reconnaître le succès des distributeurs gaziers à livrer les programmes en efficacité énergétique et à préserver les tarifs aux taux les plus bas possibles. Nous encourageons TEQ à ne pas augmenter les factures de gaz naturel pour soutenir de nouveaux programmes mais l'invitons plutôt à utiliser le Fonds Vert pour financer toute activité additionnelle et complémentaire.

L'industrie lourde dans un avenir à faible teneur en carbone

Un rôle clé dans la décarbonisation de l'économie et la production de biens essentiels.
Dans le contexte d'un avenir à faible teneur en carbone, où la température augmente de moins de 1,5 ^{o}C et que l'intensité de la demande est réduite de moitié, le monde aura encore besoin de "matériel". Il y aura donc toujours un besoin de matières premières comme les minéraux, les métaux, les produits chimiques, les produits du bois et le ciment. On pourra également compter sur les nouveaux biocarburants, l'hydrogène ainsi que les matériaux synthétiques et biosourcés.

Le Québec a un avantage concurrentiel de long terme évident en tant que fournisseur de produits à faible teneur en carbone. La capacité existante de production d'hydro-électricité jumelée au potentiel de développement des énergies solaire, éolienne, de la biomasse, de ses ressources minières ainsi que de l'énergie de l'océan pourraient permettre au Québec de se distinguer et de préserver son économie. Pour maintenir son avantage concurrentiel de long terme, le Québec se doit de capitaliser sur son énergie propre, ses ressources naturelles et humaines et sur sa base industrielle.

L'ACIG s'est associée aux travaux d'un chercheur de renom, Dr Chris Bataille, sur l'initiative de décarbonisation profonde parrainée par les Nations Unies, visant à comprendre le rôle de l'industrie lourde dans un avenir à faible teneur en carbone, à explorer le potentiel technique de la décarbonisation de l'industrie lourde et enfin à développer des occasions de recherche et d'investissement pour retenir l'industrie au Québec et en Ontario et aussi attirer de nouvelles industries.

Les résultats de recherche du Dr Bataille indiquent qu'il est techniquement possible de décarboniser toute l'industrie lourde. Toutefois, les solutions ne sont pas toutes disponibles immédiatement dans le marché. Plusieurs projets de développement ne sont pas encore disponibles sur une base commerciale, mais plusieurs ont déjà atteint un état d'avancement variant du concept éprouvé au projet de démonstration. Il faudra entre un à deux cycles d'investissement pour transformer les installations industrielles existantes. Le rapport d'étude du Dr Bataille, les données qui appuient le rapport ainsi qu'un sommaire préparé par l'ACIG sont joints[1] au présent mémoire.

[1] Les pièces jointes sont en anglais. Une traduction du rapport et du sommaire est en cours et attendue vers la fin du mois de janvier 2018. La version française sera substituée à la version anglaise dès que disponible.

Le Québec doit avoir une vision claire et de long terme pour les grandes industries qui exploitent des installations à forte intensité énergétique et qui sont exposées au commerce international. Cette vision doit reconnaître la nature mondiale du commerce des produits de base et inciter le gouvernement à investir dans l'industrie lourde qui est exposée au commerce afin de la protéger de la concurrence exogène. Afin de préserver son économie, il est primordial d'élaborer un plan de transition qui sauvegardera la compétitivité des industries québécoises et ainsi éviter les fuites économiques et l'exportation des émissions de GES.

Cette vision est essentielle à l'élaboration de politiques d'encadrement qui inciteront à la décarbonisation de l'économie.

L'ACIG comprend à la lecture du document Fiche Diagnostic / Enjeux, préparé par TEQ pour assister la consultation, que la réduction des émissions est en partie attribuable à la fermeture d'usines. Nous soumettons respectueusement que dans un contexte où le monde continuera de consommer des biens et aura besoin de matières premières, une usine qui ferme au Québec implique que la production est déplacée vers une autre juridiction et ne garantit aucunement de baisses réelles d'émissions. Il importe de préserver l'avantage économique que détient le Québec en préservant sa base industrielle. De telles fuites économiques et l'exportation des émissions ne sont pas souhaitables.

Une opportunité pour le Québec d'assumer son leadership

Le Québec doit se positionner comme chef de file dans le dialogue canadien. Il doit s'assurer que les industries demeurent compétitives et tiennent un rôle de premier plan dans la transition vers une économie à faible carbone. Le Québec doit faire valoir son avantage concurrentiel de long terme pour soutenir le discours canadien et contribuer à l'établissement du cadre mondial de décarbonisation de l'industrie lourde.

Le Québec possède un double incitatif à contribuer au positionnement du Canada comme leader à l'échelle mondiale. En effet, les champions européens de la lutte au changement climatique n'ont pas les ressources naturelles que détient le Québec. De plus, afin de préserver son économie régionale, le Québec se doit de soutenir la présence actuelle d'une grande concentration d'industries à forte intensité énergétique qui sont exposées au commerce international. Ce qui est perçu comme une menace doit se transformer en opportunité de positionnement stratégique et se traduire en un avantage concurrentiel de long terme.

Le positionnement stratégique du Québec est primordial afin d'éviter l'exportation des émissions de carbone par la relocalisation des industries sur des territoires voisins. Globalement, aucune victoire de réduction de GES ne peut être revendiquée si elle est directement associée à une perte pour l'économie locale, tel que la fermeture d'usines.

L'industrie lourde est un atout pour le Québec et un partenaire volontaire pour atténuer le changement climatique. Il faut veiller à la valorisation de l'industrie et reconnaître son rôle dans l'économie.

L’exemplarité du Québec doit s’afficher dans l’approvisionnement des services publics

La politique gouvernementale doit valoriser et prioriser l’utilisation de produits fabriqués par des procédés à faible intensité de carbone. Cela commence par la reconnaissance, la différenciation et la valorisation de ces produits dans la chaîne d’approvisionnement.

Le gouvernement ne doit pas se limiter à développer sa réglementation environnementale. Il importe que le Québec prêche par l’exemple et reconnaisse la valeur des efforts déployés par l’industrie dans la réduction des GES. Les politiques d’approvisionnement du secteur public devraient refléter cette réalité et prioriser les produits fabriqués localement par des procédés à faible teneur en carbone.

À l’instar des pays de l’Europe qui ne défient pas les pratiques de l’Organisation mondiale du commerce (OMC), le Québec doit permettre la différenciation des produits à faible émission de carbone et leur valorisation.

Conclusion

L’ACIG souhaite que, dans l’élaboration de son premier plan directeur visant à réduire les émissions de carbone, Transition énergétique Québec s’assurera que l’industrie lourde au Québec aura l’opportunité d’effectuer sa transition vers une économie faible en carbone sans perte de production vers d’autres juridictions.

Tout investissement dans l’industrie lourde au Québec pour éviter les fuites économiques contribuera à l’atteinte des objectifs de décarbonisation de l’économie et maintiendra la richesse économique du Québec.

Récapitulatif

- Même dans un avenir à faible teneur en carbone, le monde aura besoin de plus de matériaux conventionnels de base (minéraux, métaux, produits chimiques, produits du bois) ainsi que de nouveaux matériaux biosourcés.

- Le Québec aura un avantage concurrentiel de long terme en tant que fournisseur de produits à faible teneur en carbone s'il maintient et décarbonise son industrie lourde.

- Le Québec a besoin d'une vision claire et d'un plan de transition qui:

  - Reconnaît la nature mondiale du commerce des produits de base;
  - Investit dans la décarbonisation de son industrie lourde;
  - Protège l'industrie exposée au commerce de la concurrence exogène;
  - Empêche les fuites économiques et l'exportation des émissions.

- Le gouvernement devrait adopter un comportement exemplaire en appliquant une politique d'approvisionnement des services publics qui valorise les produits à faible émission de carbone.

Le tout respectueusement soumis.

Shahrzad Rahbar, PhD, ICD.D
Présidente

Annexe 1 – Liste des membres de l'ACIG

Air Liquide

Arcelor Mittal Dofasco

Arcelor Mittal Produits Longs Canada

Arlanxeo Canada Inc.

Atlantic Packaging Products Ltd.

Cascades CS+ Inc.

CGC/USG Corporation

Cytec Solvay Group

Domtar Inc.

Gerdau Long Steel North America

Greenfield Global

INEOS Styrolution Canada Ltd.

Invista (Canada)

Ivaco Rolling Mills

Matériaux innovants Rayonier (jusqu'à récemment Tembec)

Wabrasives Inc.

Résolu, Produits forestiers

Rio Tinto

Sudbury Integrated Nickel

Suncor Energy Marketing Inc.

Vale Limited

Walker Industries Holdings Limited

ANNEXES JOINTES AU MÉMOIRE

Industry	Technology or process type	Technology or process name	Description	State of development	GHG impact	Energy impact	Cost	Policy	Considerations for application in Canada	Reference type	Reference links
				Current standard, commercial, pilot, R&D, conceptual?	Quantify in relative to current standard	Does the technology require greater or lesser energy consumption? Different fuel?	Capital, $/t CO_2, other	Have any jurisdictions implemented policies (e.g. R&D) to pursue this technology?		References should be peer-reviewed or from otherwise reputable sources.	Live link
Cement											
Cement	Current Technology	Portland Cement	Calcium compounds, silica, alumina and iron oxide are placed in rotating kiln at 1500C.	Current Standard	0.5171 tCO_2/t of clinker	5.62 TJ/ t clinker					CIEEDAC
Cement	New decarbonization technology/process	Novacem	Cement composed of magnesium oxide and hydrated magnesium carbonates. Produced at lower temperature (180C vs 1250C) and pressure to reduce combustion emissions, as well as allow for biofuel substitution. Absorbs more CO_2 than is produced during the process, leading to an absorption of ~100kg CO_2 per tonne cement produced. Product is air permeable.	Conceptual	Absorbs 100kg CO_2/t clinker	30% less than OPC	Magnesium is not very common on land, making this option more expensive			Survey academic article covering novel methods of cement production.	http://www.sciencedirect.com/science/article/pii/S2212609013000071
Cement	New decarbonization technology/process	Calera	Cement production that mimics coral reefs. CO_2-rich flue gas is filtered through seawater. Calcium and magnesium are stripped from seawater to create cement as strong as OPC, and air permeable (potential building efficiency benefits). Similar product to Novacem but different process.	Conceptual	Essentially would be carbon neutral, as carbon comes from recycled effluent	Less				Survey academic article covering novel methods of cement production.	http://www.sciencedirect.com/science/article/pii/S2212609013000071
Cement	New decarbonization technology/process	Alkali-Activated Cement	Aluminum-silicon based cement, made from sand, water, natural or synthetic pozzolands and an alkali activator. Competitive in terms of cost with OPC as well as strength.	Pilot	95% less emissions than standard OPC	Less				Survey academic article covering novel methods of cement production.	http://www.sciencedirect.com/science/article/pii/S2212609013000071
Cement	New decarbonization technology/process	Calix	Produced in a reactor by rapid calcination of dolomitic rock in superheated steam.	Pilot				New Build Only	Acceptance and confidence in durability	Technology Roadmap	https://www.iea.org/publications/freepublications/publication/Cement.pdf
Cement	New decarbonization technology/process	Ecocement from incinerator ash	500 kg/ton clinker replaced by incinerator ash	Pilot	50% CO_2 reduction			New Build Only		Technology Roadmap	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/230949/D13_951813__Ricardo_AEA_Industrial_Decarbonisation_Literature_Review_201___.pdf
Cement	New decarbonization technology/process	Thermoplastic carbon-based cements (C-Fix cement)	Produced as a waste/residue when crude oil is ´cracked´. C-Fix was developed by Shell and the University of Delft (NL) and needs to be heated to 200°C before being added to aggregates/fillers to make a ´carbon concrete´. It has properties in common with both asphalt and cement-based concretes but is mixed and applied using asphalt techniques.	Pilot	50% CO_2 reduction			New Build Only	Acceptance and confidence in durability	Technology Roadmap	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/230949/D13_951813__Ricardo_AEA_Industrial_Decarbonisation_Literature_Review_201___.pdf

Industry	Technology or process type	Technology or process name	Description	State of development	GHG impact	Energy impact	Cost	Policy	Considerations for application in Canada	Reference type	Reference links
				Current standard, commercial, pilot, R&D, conceptual?	Quantify in relative to current standard	Does the technology require greater or lesser energy consumption? Different fuel?	Capital, $/t CO_2, other	Have any jurisdictions implemented policies (e.g. R&D) to pursue this technology?		References should be peer-reviewed or from otherwise reputable sources.	Live link
Cement	New decarbonization technology/process	Geopolymer Cement	Utilises waste materials from the power industry (fly ash, bottom ash), the steel industry (slag), and from concrete waste, to make alkali-activated cements.	Small Scale Commercialization	50% CO_2 reduction			New Build Only	Acceptance and confidence in durability	Technology Roadmap	https://www.iea.org/publications/freepublications/publication/Cement.pdf
Cement	Cementitious substitution	Cementitious substitution	Increase use of clinker substitutes	Commercial	260 kgCO_2/tonne of cement produced (based on move from 0.88 to 0.6 tonne clinker per tonne cement)		€-25 to -30/tCO_2		Availabilty of supply of substitute materials and sutability for different applications	Technology Roadmap	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/230949/D13_951813__Ricardo_AEA_Industrial_Decarbonisation_Literature_Review_201___.pdf
Cement	Fuel switching to biomass	Fuel switching to biomass	Increase of biomass	Commercial	31% CO_2 reduction		Capital: €5-15 million for retrofit. Operational: €2-8/tonne clinker increase		Availabilty of supply and price of biomass fuels	Technology Roadmap	https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050
Glass											
Glass	New decarbonization technology/process	Oxy-fuel firing		Commercial		Between 5-20% of fuel savings compared to efficient regenerative furnaces, At least 15% more efficient than conventional air fired burner systems.	Heavily dependent on the size of the furnace			Technology Roadmap	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/230949/D13_951813__Ricardo_AEA_Industrial_Decarbonisation_Literature_Review_201___.pdf
Glass	New decarbonization technology/process	Direct Electric Melting	Electric furnace	Small Scale Commercialization	Eliminate fossil fuel combustion emissions	Relatively more efficient	Driven by cost of electricity	New Build Only		Technology Roadmap	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/230949/D13_951813__Ricardo_AEA_Industrial_Decarbonisation_Literature_Review_201___.pdf
Iron and Steel											

Industry	Technology or process type	Technology or process name	Description	State of development	GHG impact	Energy impact	Cost	Policy	Considerations for application in Canada	Reference type	Reference links
				Current standard, commercial, pilot, R&D, conceptual?	Quantify in relative to current standard	Does the technology require greater or lesser energy consumption? Different fuel?	Capital, $/t CO_2, other	Have any jurisdictions implemented policies (e.g. R&D) to pursue this technology?		References should be peer-reviewed or from otherwise reputable sources.	Live link
Iron and Steel	Current Technology	BF-BOF	Blast furnace + basic oxygen furnace technology for the majority of production, Electric Arc Furnace EAF also used for recycling steel.	Current Standard	Global average: 2.1 tCO_2/tonne steel BF-BOF +0.2 casting and rolling;	10 GJ/t				Literature review	Denis-Ryan, A., C. Bataille & F. Jotzo (2016): Managing carbon-intensive materials in a decarbonizing world without a global price on carbon, Climate Policy, DOI: 10.1080/14693062.2016.1176008. Supplemental material
	Current Technology	EAF	Electric Arc Furnace	Current Standard	EAF depends on electric GHG intensity plus +0.2 casting and rolling.					Literature review	Denis-Ryan, A., C. Bataille & F. Jotzo (2016): Managing carbon-intensive materials in a decarbonizing world without a global price on carbon, Climate Policy, DOI: 10.1080/14693062.2016.1176008. Supplemental material
	Current Technology	DRI-EAF	The DRI process uses natural gas (90% globally) or coal (10%, mainly in India) for energy and a syngas of hydrogen and carbon monoxide as the reductant. After reduction, the metallic iron is then melted in an EAF	Current Standard	1.4 tCO_2/tonne + EAF needs + 0.2 casting and rolling				EAF are irutaully GHG free in hydroprovinces: Quebec, Manitoba and BC.	Literature review	Denis-Ryan, A., C. Bataille & F. Jotzo (2016): Managing carbon-intensive materials in a decarbonizing world without a global price on carbon, Climate Policy, DOI: 10.1080/14693062.2016.1176008. Supplemental material
Iron and Steel	New decarbonization technology/process	Cyclone Converter Furnace	Pre-reduction and final reduction of iron ore takes place at different levels within the same cyclone, reducing heat losses of different steps. Oxygen and coal (or other biomass) is introduce at the bottom of the cyclone.	R&D	Less	20% reduction				Survey peer-reviewed article covering novel methods of Iron and Steel production.	http://www.sciencedirect.com.proxy.lib.sfu.ca/science/article/pii/S136403211400152X

Industry	Technology or process type	Technology or process name	Description	State of development	GHG impact	Energy impact	Cost	Policy	Considerations for application in Canada	Reference type	Reference links
				Current standard, commercial, pilot, R&D, conceptual?	Quantify in relative to current standard	Does the technology require greater or lesser energy consumption? Different fuel?	Capital, \$/t CO_2, other	Have any jurisdictions implemented policies (e.g. R&D) to pursue this technology?		References should be peer-reviewed or from otherwise reputable sources.	Live link
Iron and Steel	New decarbonization technology/process	Smelt Reduction (Coke free steel making)	HIsarna technology uses a bath-smelting technology and produces a more energy efficient and less carbon intensive steel. It combines a number of processes, preheating of coal, partial pyrolysis in a reactor, an ore melting cyclone and a vessel for ore reduction.	Pilot	20% CO_2 emission reductions		Estimates are that both capital and operating expenditures would be lower.		Requires replacement of entire blast furnace	Technology Roadmap	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/230949/D13_951813__Ricardo_AEA_Industrial_Decarbonisation_Literature_Review_201___.pdf
Iron and Steel	New decarbonization technology/process	Paired Straight Hearth (PSH) Furnace	Pellets of Iron and high-volatility Coal are heated and reduced to 95% metallized pellets suitable for use in an EAF. The product of reduction (CO gas) is released and heated above the bed to drive the process. More efficient than traditional Blast Furnace.	Pilot	33% reduction per t of hot metal produced	30% reduction compared to blast furnace	$16.7 M for facility producing 46,000 t a year of DRI			Survey peer-reviewed article covering novel methods of Iron and Steel production.	http://www.sciencedirect.com.proxy.lib.sfu.ca/science/article/pii/S136403211400152X
Iron and Steel	New decarbonization technology/process	Coal-Based HYL Process	Gasified coal is used to directly reduce iron ores in a solid-gas moving bed reactor.Oxygen is removed from ores using reactions based on H_2 and CO to create highly metallized DRI. Can gasify and use pretty much any carbon-bearing fuel.	Pilot	60% reduction	Less				Survey peer-reviewed article covering novel methods of Iron and Steel production.	http://www.sciencedirect.com.proxy.lib.sfu.ca/science/article/pii/S136403211400152X
Iron and Steel	Increased used of recycled steel	Increased used of recycled steel	Most virgin steel is made using the BF-BOF process, while recycled steel is almost entirely produced using an electric arc furnace. The lower the GHG intensity of electricity, the lower the process GHG intensity. According to J. Allwood, in most developed coutnires there is sufficent recyclable steel available to meet all needs, but it tends to be contaminated with tin and copper. If these could be seperated, either through design or labour, the mix of recycled steel in the overall mix could rise.	Conceptual, would require industrial reorgnisation	up to -99%, -50-75% given recyling estimates	Less			Highly applicable to Canada, given our existing vehicle and building stock.	Survey. Document not pee reviewed but based on peer reviewed literature.	https://www.cam.ac.uk/system/files/a_bright_future_for_uk_steel_2.pdf
Iron and Steel, Chemicals	New decarbonization technology/process	MOE	Molten oxide electrolysis for steel production with iron-chromium alloy anode. Electricity will drive the process instead of fossil fuel combustion, with carbon added to form steel simply as needed.	R&D	80% reduction compared to blast furnace per t of liquid steel	Uncertain				Survey peer-reviewed article covering novel methods of Iron and Steel production.	http://www.sciencedirect.com.proxy.lib.sfu.ca/science/article/pii/S136403211400152X
Metal Processing											
Mining, Metal Processing, Chemicals	New decarbonization technology/process	Solar Thermal Process Heat	Solar thermal steam heating can be applied to manufacturing processes requiring temperatures up to 400C. For example, there is a 50 GWh solar thermal installation at a copper mine in Chile.	Pilot		Uncertain				Industry association publication	http://irena.org/remap/REmap%202030%20Renewable-Energy-in-Manufacturing.pdf

Industry	Technology or process type	Technology or process name	Description	State of development	GHG impact	Energy impact	Cost	Policy	Considerations for application in Canada	Reference type	Reference links
				Current standard, commercial, pilot, R&D, conceptual?	Quantify in relative to current standard	Does the technology require greater or lesser energy consumption? Different fuel?	Capital, $/t CO_2, other	Have any jurisdictions implemented policies (e.g. R&D) to pursue this technology?		References should be peer-reviewed or from otherwise reputable sources.	Live link
Metal processing	New/repurposed decarbonization technology/process	Switiching from pyrolytic to hydrolytic processes		R&D	Case specific.						

Industry	Technology or process type	Technology or process name	Description	State of development	GHG impact	Energy impact	Cost	Policy	Considerations for application in Canada	Reference type	Reference links
				Current standard, commercial, pilot, R&D, conceptual?	Quantify in relative to current standard	Does the technology require greater or lesser energy consumption? Different fuel?	Capital, $/t CO₂, other	Have any jurisdictions implemented policies (e.g. R&D) to pursue this technology?		References should be peer-reviewed or from otherwise reputable sources.	Live link
Mining											
Mining	Current Technology	Release of VAM	Currently Methane emissions leaking from coal mines are released into the atmosphere, at high flow rates but low methane volumes (0.2% - 1.0%) accounting for ~15% of mining emissions.	Current Standard							
Mining	New decarbonization technology/process	Stone Dust Looping Process	Coal mines emit Ventilation Air Methane (VAM) at concentrations of <2%. However these are significant source of emissions. This technology catalytically oxidizes methane before carbonating and calcinating in a fluidized bed. Essentially turning Methane into CO_2 and then capturing CO_2.	Conceptual	Depends on starting mine site emissions	Uncertain				Peer-reviewed article	http://www.sciencedirect.com/science/article/pii/S0378382015301089
Mining	New decarbonization technology/process	VamTurBurner	Technology for reducing VAM from coal mines. Essentially a turbine which combusts methane, using heat exchangers to produce electricity as well as heat incoming gas. Can lead to higher efficiency burning as well as turning a source of emissions into useful product.	Conceptual	Depends on starting mine site emissions	Less				Peer-reviewed article	http://www.sciencedirect.com/science/article/pii/S135943111500455X
Mining	New decarbonization technology/process	Switching mine trucks to hybrid diesel/electric motors, that can be driven using overhead wiring		Technology well known, has not been applied in this sector	Depends on access to electricity at remoate mine site, plus GHG content of electricity. Material available, need to fill out		If new build and electricity available, could be net negligible because of the cost fop transporting in diesel.		Some mine sites are close to decarbonized electricity (e.g. .in the Yukon and NWT), some are not.	Consulting review report	Provide link to BC hydro MKJA report on electrification, TBD.
Mining	New decarbonization technology/process	Use of electric conveyor belts to move ore instead of diesel trucks		Commercial	Depends on access to electricity at remoate mine site, plus GHG content of electricity. Material available, need to fill out		If new build and electricity available, could be net negligible because of the cost fop transporting in diesel.		Some mine sites are close to decarbonized electricity (e.g. .in the Yukon and NWT), some are not.	Consulting review report	Provide link to BC hydro MKJA report on electrification, TBD.

Industry	Technology or process type	Technology or process name	Description	State of development	GHG impact	Energy impact	Cost	Policy	Considerations for application in Canada	Reference type	Reference links
				Current standard, commercial, pilot, R&D, conceptual?	Quantify in relative to current standard	Does the technology require greater or lesser energy consumption? Different fuel?	Capital, $/t CO_2, other	Have any jurisdictions implemented policies (e.g. R&D) to pursue this technology?		References should be peer-reviewed or from otherwise reputable sources.	Live link
Refineries											
Refineries	Current Technology	Current Technology	Currently refineries do not employ any method of capturing CO2 emissions, either by filtration, adsorption or scrubbing.	Current Standard	0.35 t CO2/ m3 output						
Refineries	Energy Efficiency	Waste Heat and Energy Recovery	High efficiency energy recovery units for exporting heat to local industrial or domestic users or electricity to grid (fluid catalytic cracking units, hydrocracking units, coking units)	Commercial	10% Reduction		Project Investment is more than 5 million pounds		Requires a demand for waste heat	Technology Roadmap	https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050
Refineries	New decarbonization technology/process	Air source capture combined with hydrogen sourced from renewable electricity to make liquid fuels		Pilot	Depending on how done, could be -99%					Website with peer reviewed sources	http://carbonengineering.com/publications/
Refineries	New decarbonization technology/process	Post-Combustion Membranes	Membrane technology used to adsorb or separate CO2 from flue gas. Captured CO2 would be condensed. Low maintenance.	R&D	Up to 95% reduction	None	$48/t (75% removal) - $71/t (90% removal)			Peer-reviewed article	https://www.researchgate.net/publication/271588841_Membrane-based_carbon_capture_from_flue_gas_A_review
Chemicals											
Chemicals	Current Technology	Current Technology	Chemical manufacturing in Ontario/QC has GHG per output of around 0.80 tCo2/t output. Most processes used chemical catalysts, which require higher temperature and energy input than biological processes.	Current Standard	~0.80 t CO2 / t output						
Chemicals - Methanol	New decarbonization technology/process	Carbon Dioxide to Renewable Methanol	Methanol produced from flue gases that contain a high concentration of carbon dioxide and hydrogen. This process consists of a system of electrolytic cracking and catalytic synthesis that leads to a low pressure and low temperature electrochemical production of methanol.	Pilot	100% Reduction (potential for net sequestration 1.13 tCO2e/t of methanol)		USD$8.4 million for 50 million litre facility	New Build Only	Technology must be deployed near an industrial site that can produce high CO2 waste streams.	Non peer-reviewed article	http://www.chemicals-technology.com/projects/george-olah-renewable-methanol-plant-iceland/
Chemicals - Olefins	New decarbonization technology/process	Olefins: Catalytic Cracking of Naphtha	Olefins (ethylene, propylene, etc.) usually produced by steam cracking, which is energy intensive. These can be created by catalytically cracking Naphtha instead, which requires less energy.	Pilot		30 - 40% less				Peer-reviewed article	http://www.sciencedirect.com.proxy.lib.sfu.ca/science/article/pii/S0016236116000612
Chemicals - Olefins	New decarbonization technology/process	Olefins: Methane to Olefins	Make olefins from natural gas via methanol, replacing the current process of steam cracking of naptha or ethane	Pilot	10% reduction	reduces fossil fuel by about 66%		New Build Only		Technology Roadmap	https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050

Industry	Technology or process type	Technology or process name	Description	State of development	GHG impact	Energy impact	Cost	Policy	Considerations for application in Canada	Reference type	Reference links
				Current standard, commercial, pilot, R&D, conceptual?	Quantify in relative to current standard	Does the technology require greater or lesser energy consumption? Different fuel?	Capital, $/t CO_2, other	Have any jurisdictions implemented policies (e.g. R&D) to pursue this technology?		References should be peer-reviewed or from otherwise reputable sources.	Live link
Chemicals - Ethylene	New decarbonization technology/process	Olefins: Bio-ethylene	Bio-ethylene from bio-ethanol. The bio-ethanol is converted to bio-ethylene by an alumina or silica-alumina catalyst.	Small scale commercialization	69% Reduction, 0.057 tCO2e/t product (vs. natural gas)		16 Euros/tCO2e	New Build Only		Technology Roadmap	http://www.cedelft.eu/publicatie/identifying_breakthrough_technologies_for_the_production_of_basic_chemicals/1221
Chemicals - Ethylene	New decarbonization technology/process	Catalytic Coating of Coils	Reducing coking can greatly improve heat transfer in furnaces. A novel catalytic coating is applied to the internal surfaces of tubes and coils that can greatly reduce coke formation and also allow higher ethylene selectivity.	Pilot	6% reduction	6-10% reduction				Non peer-reviewed article	http://energy.gov/sites/prod/files/2015/06/f22/1001-High-Value%20Chemicals-061015_FINAL.pdf
Chemicals - Aromatics	New decarbonization technology/process	Lignin to Aromatics	Lignin (mainly from woody biomass) can be used as a feedstock for producing aromatics. Lignin must be first depolymerized and defuncionalized. Energy impact is probably greater, but GHG's associated with life cycle will be lower.	Conceptual	Less	More				Non peer-reviewed article	https://www.iea.org/publications/freepublications/publication/Chemical_Roadmap_2013_Final_WEB.pdf
Chemicals	Current Technology	Steam Reforming Hydrogen Production	Steam and methane combine to create syngas; oxygen is then strippe dfrom water to oxidize CO to CO_2.	Current Standard	9 - 12 t CO_2 / t Hydrogen						
Chemicals - Hydrogen	New decarbonization technology/process	Photocatalytic Hydrogen Production	Creation of hydrogen from water through photocatalytic processes that already occur in photosynthesis through complex biological reaction pathways. Lots of energy input required, but does not require fossil fuels.	Conceptual	Less	More				Non peer-reviewed article	https://www.iea.org/publications/freepublications/publication/Chemical_Roadmap_2013_Final_WEB.pdf
Chemicals - Ammonia	New decarbonization technology/process	Solid State Synthesis	Solid state ammonia synthesis using electricity	Pilot				New Build Only		Technology Roadmap	https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050
Chemicals - Ammonia	New decarbonization technology/process	Low pressure catalyst for ammonia synthesis	Synthesis of ammonia takes place on an iron catalyst at lower pressure and temperature. Catalysts utilizing ruthenium allow even lower pressure	Early Commercialization	7% Reduction						
Chemicals - Ammonia	New decarbonization technology/process	Biomass gasification to produce syngas	Replacing natural gas feedstock with syngas from biomass for low carbon source of hydrogen for the production of ammonia	Commercial	63% Reduction		300-400 Euros / Mtonne NH_3 produced, ~31 Euros/tonne	New Build Only	Sourcing of biomass	Technology Roadmap	http://www.cedelft.eu/publicatie/identifying_breakthrough_technologies_for_the_production_of_basic_chemicals/1221

Industry	Technology or process type	Technology or process name	Description	State of development	GHG impact	Energy impact	Cost	Policy	Considerations for application in Canada	Reference type	Reference links
				Current standard, commercial, pilot, R&D, conceptual?	Quantify in relative to current standard	Does the technology require greater or lesser energy consumption? Different fuel?	Capital, $/t CO_2, other	Have any jurisdictions implemented policies (e.g. R&D) to pursue this technology?		References should be peer-reviewed or from otherwise reputable sources.	Live link
Chemicals - Chlorine	New decarbonization technology/process	Retrofit ODC for chlorine production	Retrofit Oxygen Depolarised Cathode (ODC) to membrane cells	Small Scale Commercialization	23% reduction	23% reduction				Technology Roadmap	https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050
Chemicals - Styrene	New decarbonization technology/process	Dehydrogenation in carbon dioxide	Carbon dioxide acts as a diluent, shifting and enhancing the equilibrium conversion. The process also improves selectivity and provides improved heat delivery due to high heat capacity.	Pilot	40% Reduction	2.5 GJ/t-styrene, compared to 6.3 GJ/tonne styrene for the current process	Retrofit $US10-15 million (250,000 t/yr plant)			Non peer-reviewed article	https://www1.eere.energy.gov/office_eere/pdfs/exelus_case_study.pdf
Chemicals - Generic	New decarbonization technology/process	Membrane Technology	Deploy membrane technologies to replace more energy intensive separation technologies such as distillation	Pilot	8% reduction	8% reduction				Technology Roadmap	https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050
Chemicals - Generic	New decarbonization technology/process	Use of enzymatic versus chemical catalytic process	Use of fermentation and enzymatic processes instead of chemical processes with catalytic reactions. Biological processes take place at lower temperature and pressures, reducing energy demand by as much as 50%. An example with the greatest potential worldwide is ethylene produced from bioethanol, instead of petrochemical feedstock.	Conceptual		Up to 50% less	$1-5 /tonne of CO2 saved			Peer-reviewed article	http://www.sciencedirect.com.proxy.lib.sfu.ca/science/article/pii/S0734975015300306

Industry	Technology or process type	Technology or process name	Description	State of development	GHG impact	Energy impact	Cost	Policy	Considerations for application in Canada	Reference type	Reference links
				Current standard, commercial, pilot, R&D, conceptual?	Quantify in relative to current standard	Does the technology require greater or lesser energy consumption? Different fuel?	Capital, $/t CO_2, other	Have any jurisdictions implemented policies (e.g. R&D) to pursue this technology?		References should be peer-reviewed or from otherwise reputable sources.	Live link
Pulp and Paper											
Pulp and Paper	Biomass and clean electricity	NA	The majority of emissions are associated with heat and steam production, as well as electricity. According to the EPA (see reference), increasing biomass and clean electricity compared to natural gas is the best feasible abatement option.	Commercial						Non peer-reviewed article	https://www.epa.gov/sites/production/files/2015-12/documents/pulpandpaper.pdf
All sectors											
Metal Processing, Iron and Steel, Chemicals, Cement and Glass	New decarbonization technology/process	Chemical Looping Combustion	A combustion process with an oxygen carrier circled between two fluidized bed reactors: an Air Reactor and a Fuel Reactor. Oxygen carrier is oxidized by introduction of air in AR. Gaseous fuel then reacts with oxygen on oxygen carrier in the FR. Carriers are usually a metal (Ni or Fe are common).	Conceptual	95% CO_2 capture	Uncertain				Peer-reviewed article	http://www.sciencedirect.com.proxy.lib.sfu.ca/science/article/pii/S1364032116000319

Options, Opportunities and the Efficient Transition

A Report on the Technical Potential to Decarbonize Canada's Heavy Industry

Industrial Gas Users Association / l'Association des consommateurs industriels de gaz
260 Centrum Boulevard, Suite 202, Orleans, ON, K1E 3P4 Tel (613) 236-8021 Fax: (613) 830-7196 Email: info@igua.ca

IGUA | ACIG

Executive Summary

Maintaining a maximum increase of 1.5-2°C in atmospheric temperature rise involves substantially decreasing CO2 emissions by 2050 and reducing them to net zero by 2075. However, Canada and the world will still need the material stuff of modern life. IGUA partnered with Dr. Christopher Bataille, who is one of the leading economists working on deep decarbonisation under the UN framework, to examine the technical potential for decarbonizing Canada's heavy industry. The purpose of the study was to inform the policy discourse underway today and facilitate setting a transition path towards eventual decarbonisation of heavy industry.

The Bataille study[1] catalogued the range of potential technology options for each sector, gauged their market readiness and identified policy opportunities for transitioning heavy industry to a low-carbon future. The industry sectors that the study focussed on were steel, mining, metals processing, forestry/pulp and paper, petrochemical, chemical, cement and glass.

Key findings:

- The world will need materials even in a low carbon future with half of today's material intensity;
- Technically feasible decarbonisation options exist for almost all heavy industry sectors in Canada using a combination of generic technologies and total process redesign;
- There are no commercially available technologies for retrofitting existing sites industrial facilities. Most technologies are in various stages of development;
- Canada can have a competitive advantage as a supplier of low-carbon (eventually carbon-free) commodities in a low-carbon future because we have the resource endowment, the trained workforce, the research capability and the industry;
- The enabling policy considerations required for transitioning heavy industry to a low-carbon future are:
    - Recognizing and accommodating the high-capital and long-term investment cycles of industry.
    - Developing a common vision and plan of action for heavy industry that accommodates de-carbonization pathways for each large operation based on regionally specific circumstances, and coordinates research, commercialization and labour force training.
    - Investing in R&D

The present report provides an overview of the Bataille technical potential study, and highlights the notable findings.

[1] *Reference Bataille Study*

Introduction

About IGUA

The Industrial Gas Users Association represents the interests of large mining, steel, pulp and paper, chemicals, refineries and manufacturing companies in Ontario and Québec in energy matters. IGUA member companies collectively employ 24,000 people in Canada and 750,000 people worldwide. They are significant sources of revenue for the federal and provincial governments and key engines of development in their local communities.

Context

In the past two years climate change has become a key focus of many provinces and the federal government. Alberta and Ontario have released new climate change plans; and Quebec and British Columbia have reaffirmed their existing plans . The federal government has re-engaged in international climate negotiations, and in November of 2015 signed the Paris Accord to limit greenhouse gas emissions needed to keep global temperature rise below 2 degrees Celsius. It has been in consultation with the provinces since then and is expected to release a Canada wide climate change plan this fall.

Most of the discourse in Canada on climate and energy however has lacked insight on opportunities and pathways for heavy industry (other than oil and gas producers) to reduce carbon emissions. This has been largely due to the fact that large facilities like mines, chemical plants, refineries, steel plants or paper mills are not readily comparable with one another, and also because reducing the carbon intensity of heavy industry requires more than the effective policy tools for residential and commercial sectors like energy efficiency and electrification. Little work has gone into understanding options for decoupling green house gas emissions from energy use in heavy industry.

Looking beyond Canada, different countries have adopted different pathways for carbon reduction to suit their particular economic fabric. Germany has focused on becoming a global leader in low emissions industry, and introduced policy instruments to grow its industrial base while reducing energy intensity of its economy. The United Kingdom has opted for de-industrialization as its path to lowering carbon emissions. Each government has opted for the option that gives it the most competitive advantage in the future. Canada needs to do the same; federal and provincial governments need to deploy policy instruments that reflect Canada's economic strengths and provide Canada with a competitive advantage in a low carbon future.

IGUA partnered with Dr. Christopher Bataille[2], who is one of the leading economists working on deep decarbonisation under the UN framework, to examine the technical potential for decarbonizing Canada's heavy industry. The purpose of the study was to inform policy discourse and facilitate setting a transition path towards eventual decarbonisation of heavy industry in Canada.

---

[2] Dr. Bataille is the co-leader of the Canadian Deep Decarbonization Pathways Project (DDPP), member of the global DDPP secretariat, Associate researcher with the Institute for Sustainable Development and International Relations (IDDRI) in Paris and Adjuct Professor at Simon Fraser University. He has a PhD in energy and climate change policy modeling from Simon Fraser University.

The present report is a based on the detailed report provided by Dr. Bataille, which is attached for reference.

Scope

The study set out to explore the implications of decarbonisation for Canadian non-fossil fuel extraction heavy industry, and identify options of adaptation. The energy and emissions intensive industries sectors targeted in the study were:

- Cement
- Glass
- Iron and Steel
- Metal Processing
- Mining
- Refineries
- Chemicals
- Pulp and paper

Research Questions

- Can heavy industry continue to operate and grow in Ontario and Québec, and more generally Canada, in a world committed to decarbonizing?

- What options exist to decarbonize heavy industry?
    - What are the competitiveness implications of these options?
    - What positive approaches have other countries, regions, companies or institutions taken to meet these challenges?

Approach & Methods

The technical potential study was designed to provide an initial scoping survey of technologies that can reduce green house gas emissions in the heavy industry sectors identified above. It was not designed to be an exhaustive or in-depth review of the existing facilities and options open to them, which would have required another scale of resources. The study, therefore, confined itself to a quality literature review of the technical potential for decarbonizing heavy industry, using only peer-reviewed academic and trade literature and websites based on them.

The findings are catalogued in a database, to serve as a platform for DDPP and other researchers to monitor technology options and to update the database over time. The database is not meant to be exhaustive but demonstrative of what is possible, and is meant to be the prototype for a living document that would be maintained and curated at an appropriate institution, and to provide policy makers a window into the advancements being made in industrial decarbonisation.

The technical potential study has assumed a future world where a priority is made to maintain a global temperature increase of maximum 1.5 – 2 degrees Celsius and maximum dematerialization has been pursued. It has not delved into the policy intricacies needed to bring about the concerted global action to get to such a future. It has, however, identified key the policy considerations required to make a successful transition to a low-carbon future.

Key Findings

The world will need materials in a low carbon future

Global projections for material consumption[3] in a low carbon world show that:

- More of today's bulk conventional materials (iron, steel, cement, glass, metals, chemicals and forest products) will be needed even when maximum dematerialization has been pursued and where material intensity has reduced by half.
- There will be additional demand for new low-carbon bulk commodities such as hydrogen, biofuels, polygeneration of electricity and chemicals, and synthetic hydrocarbon gas and liquids.

The low carbon world will, therefore, still need heavy industry to produce the bulk materials and finished products. The imperative is to de-couple greenhouse gas emissions from the production process, and aim for net-zero carbon industrial operations. Industry cannot expect to be a significant part of the world's carbon budget.

Canada stands among a very small group of developed countries that have a deep natural resource base and the technological knowhow to turn the natural resource endowment into bulk commodities and finished products. The question for Canada is whether it can turn its sizeable resource endowment, knowhow and industrial base to a competitive advantage and reap the social and economic benefits of being a global leader in the carbon free production of commodities.

Energy Efficiency and Electrification Are Necessary but Not Sufficient

According to the International Energy Agency[4] , if the current best available technologies (BAT) were implemented in every industrial facility across the planet, global energy demand (and GHG emissions) from industry would reduce by around 20%. This is because many energy-intensive production processes are already near BAT for competitive reasons.

Canada's forestry and pulp/paper sector has reduced reliance on fossil fuel by 75%, using bio-mass from own process instead, in order to reduce operating cost. Canada's deep mines have innovated and extract material at a much lower energy and emissions intensity than competitors operating in jurisdiction with much lower labour costs. Canada's petrochemical industry and refineries use natural gas as feedstock when most of the rest of the world uses oil.

---

[3] Denis-Ryan, A., C. Bataille & F. Jotzo (2016): Managing carbon-intensive materials in a decarbonizing world without a global price on carbon, Climate Policy, DOI: 10.1080/14693062.2016.1176008

[4] IEA, 2014, Energy Technology Perspectives 2014: Harnessing Electricity's potential. Organization for Economic Co-operation and Development, Paris.

There is a growing consensus that additional measures beyond energy efficiency technologies are needed for heavy industry to approach net zero emissions. Breakthrough new processes technologies and wide spread adoption of combustion innovations such as using bio or synthetic hydrocarbons, oxy-hydrogen combustion and post process carbon capture use and sequestration (CCUS) become necessary. However most of these technologies use more energy than conventional best available technologies. Conversion of naturally occurring substances into hydrogen, oxygen or synthetic and bio-fuels requires energy; CCUS is even a more energy intensive process. Electrification of load where possible will also be necessary and will impose further efficiency loss from generation and transmission.

Therefore ambitious low-carbon scenarios for energy intensive industry would need to have access to a larger pool of de-carbonised electricity supply.

Generic Options Exist to Decarbonise Heavy Industry, But Not Commercially Available Affordable Options

Besides efficiency and electrification, the Bataille study identified generic approaches for reducing GHG emission in industries that have historically relied on fossil fuels, that can be classified into three categories:

- Replacing the fossil input stream for feedstock and fuel with a carbon neutral alternative such as biomass, synthetic hydrocarbons and hydrogen;
- Capturing the carbon from post process emissions, using or storing it (CCUS);
- Developing wholly new industrial processes.

Each option has its challenges.

Replacing the Input Fossil Stream – The main candidates for replacing fossil input streams into industrial facilities are biomass, hydrogen and renewable and synthetic hydrocarbons. Biomass use is limited by the availability of land base and air quality issues resulting from its combustion. It may, however, prove effective in some applications. For example using switch grass to make cellulosic ethanol for transport fuel, bio diesel for heavy freight vehicles, or using bio-charcoal as the source of carbon and energy in virgin steel making. Hydrogen can potentially be used for combustion instead of fossil hydrocarbons. However Hydrogen is not a naturally occurring substance and needs to be manufactured either through reforming natural gas or through electrolysis of water, both of which require considerable energy. Where surplus renewable power is available, manufacturing hydrogen could be a viable option. Synthetic hydrocarbons also have the potential to displace fossil input streams, however the sheer volume of fossil streams that needs to be replaced relegates these to niche applications. For example, renewable natural gas from landfill, agricultural and forestry waste could displace natural gas and still permit the use of existing natural gas distribution network and end-use technologies. Availability and volume of waste stream will limit supply.

Carbon Capture Utilization and Storage (CCUS) – Post-process carbon capture from the effluent and its reuse or storage is technically viable for most industrial facilities but could be prohibitively expensive for facilities that lack the scale of natural gas processing plants or central electricity generation plants. A further limitation is the availability of suitable storage of the captured CO2 and the need for pipeline infrastructure and transportation to the storage site. CCUS could potentially become more attractive for industrial facilities when combined with oxy-fuel combustion that results in an almost pure CO2 effluent stream eliminating the need for flue gas separation. Oxygen, however, still needs to be manufactured.

Developing Wholly New Industrial Processes – Industry can also potentially develop wholly new processes that reduce the carbon content of the product. The Bataille study reviewed and catalogued potential technologies that can replace the current processes in for the production of cement, glass, iron and steel, for metal processing, mining, refineries, chemical production and pulp and paper. Dr. Bataille identified that "there is an R&D gap in heavy industry," and most of the potential technical options "will need extensive R&D and piloting," before widespread adoption of these technologies can occur.[5] Most of the new lower carbon industrial processes were deemed not suitable for retrofitting to existing industrial facilities in Canada and identified as requiring 1-2 investment cycles even to be able to use the existing sites. There was no reliable cost data available for any of the technologies.

For example, nine technologies were catalogued in the data base for reducing emissions from the cement sector. Of these nine technical options, two are in the conceptual phase; three undergoing pilot studies, one at a small-scale commercialization and two are commercial ready. Adding another layer of complexity is that three of the pilot options and the small-scale commercial options are only available for new build facilities and cannot be retrofitted to existing plants.

A review of the potential technologies for reducing emissions from iron and steel production revealed that there are limited commercial options beyond the two standard steel making technologies (blast furnace – basic oxygen furnace and electric arc furnace with or without direct reduction) there are limited commercially proven technologies. Furthermore, of the potential new technologies still in pilot stage, the one with the most GHG reduction potential (molten oxide electrolysis with decarbonized electricity) requires 20 to 30 times more electricity than the best in class electric arc furnaces. An interesting observation related to iron and steel was the importance of introducing new product design guidelines to make separation of steel easier to increase the volume of scrap and reduce its cost.

The potential options identified for reducing GHG emissions from mining, were to either electrify operations or replace the fossil fuel input with carbon-free renewable or synthetic liquid and gaseous fuels. In the case of metal processing, the potential options included a combination of using carbon free power for crushing and replacing heat based melting with chemical leaching.

A variety of technical potential options were identified for the refinery and chemical sectors that included the use of lower temperature fermentation and enzymatic processes instead of high temperature and pressure catalytic reactions, and production of hydrogen and synthetic hydrocarbons.

Multiple technical potential options were identified for reducing GHG emissions from the and pulp and paper sectors including novel sludge drying processes, increased use of recycled fibre,

[5] Ibid p. 20.

anaerobic treatment of effluent to produce combustible bio-gasses and using lignin from biomass to produce aromatics to becoming a supplier of wood pellets for other sectors.

In summary, none of the generic options offer a "silver bullet" for reducing emissions from heavy industry in the short term since each has its own set of challenges. The sheer volume of fossil fuels that needs to be replaced is prohibitively large to be replaced by carbon free synthetic or renewable alternates in the near future. Most industrial facilities may not have the scale or location to make carbon, capture, use and storage viable. Process redesign remains 'a work in progress' for most sectors, and will largely apply only to new build. However, over time and with the right set of policies a tailored combination of the potential technical options nuanced to reflect and suit the regional circumstances can become practical and economic.

Discussion and Conclusions

Canada Can Have a Competitive Advantage as a Low Carbon Commodity Producer

Given that there will be a growing demand for conventional and new bulk commodities, production of low carbon commodities will be a competitive advantage for any country in a low carbon world.

Canada is well positioned to be a low carbon commodity producer in the future, because of our vast natural resource endowment, our trained work force and research capability and because of the industry expertise and the capital we have invested in our resource and heavy industry sector. Access to decarbonized electricity is another important advantage for Canada. We already have very clean electricity compared to the rest of the world, and we have significant potential for additional hydroelectricity and wind and solar renewables.

All of the above would suggest that Canada's path to decarbonisation should not be through de-industrialization.

Supportive Policies Required

Canada has a potentially bright future in decarbonized heavy industry. A clear policy framework needs to be put in place today, to turn this potential into competitive economic advantage in the low carbon world of the future.

- Federal and provincial governments need to send clear signal that Canada's path to decarbonisation is not through de-industrialization
- Canada and its regions need a heavy industry decarbonisation plan that builds on our competitive advantages (electrification, primary extraction and processing, reorganization of steel recycling, biomass for bio-chemical products and fuels)

- Clear carbon policy needs to be coupled with protection against unfair exogenous competition for the trade exposed commodity producers

- Consideration needs to be given to the high capital base and long-term investment cycles for sectors like mining, chemicals, steel, pulp and paper, in mapping out a viable path to decarbonizing these sectors.
- Careful planning is needed to ensure adequate combination of energy supply and infrastructure is in place to support decarbonisation of heavy industry

Industry is Ready and a Willing Partner

IGUA hopes that this study will start a dialogue among the stakeholders needed to transition Canada's heavy industry to a low carbon future. There is no question that the world will continue to need material goods. Canada has several competitive advantages owing to our natural resource bounty, ingenuity in bringing industrial goods to market and a geography that allows for a multitude of low-carbon technologies to be deployed and tested. The transition of Canada's heavy industry to a low carbon future will not happen over night. But with collaboration between governments, industry and research institutions there exists the long-term potential to remake Canada's industrial landscape and reap the economic benefits of the demand for low-carbon goods in a carbon conscious world.